M. Sc. II Year Energy studies (ES)

Semester-III

ES- 301: ATOMIC AND MOLECULAR PHYSICS

1. STRUCTURE OF ATOM (PERIODS-5 HOURS)

Various atomic models- survey-brief ideas with assumptions, postulates and shortcomings, Quantum states of an electron in an atom, Quantum numbers, Electron spin, Stern-Gerlach experiment, Vector atom model- its need/important.

Atom model for two valance electron (10 Hours)

Various coupling schemes: LL, SS, LS and jj, Pauli exclusive principle, Coupling principle, factors for LS coupling , Lande interval rule, JJ branching rule, selection rules, magnetic moment of atom, Lande g factor, Zeeman effect, intensity rules, calculation of Zeeman pattern, Paschen Back effect-LS and jj coupling and Paschen Back effect, Breits scheme for derivation of spectral terms, Pauli's exclusive principle

2. COMPLEX SPECTRA (PERIODS-5 HOURS)

Displacement law, alternation law of multiplicities, vector model for more valance electrons, Lande interval rule, inverted terms, Hund's rule, Zeeman effect and magnetic quantum numbers in complex spectra, magnetic energy and Lande g factor

Hyperfine structure (5 Hours)

Introduction, hyperfine structure and Lande interval rule, nuclear interaction with one valance electron, hyperfine structure of two or more electron, Zeeman effect in hyperfine structure, Back Gouldsmit effect in hyperfine structure.

3. PURE ROTATIONAL STRUCTURE (8 HOURS)

Rotation of linear system (classical and quantum mechanical), rigid rotator, rotational energy levels and their populations, interaction of rotation with rotating molecules, rotational spectra of rigid rotators, selection rules for linear molecules, determination of moment of inertia and bond length from rotational spectra, isotope effect on rotaional spectra, relative intensities of spectral lines

4. PURE VIBRATIONAL SPECTRA (PERIODS-6 HOURS)

Vibrations of two particles connected by spring (classical), Harmonic oscillators, vibrational energies of diatomic molecules, interaction of radiation with vibrating molecules, anharmonic oscillator, deduction of molecular properties from vibrational spectra of diatomic molecules.

Rotation and vibration spectra (4 Hours)

Diatomic vibrating rotator coupling of rotation and vibration , rotation-vibration spectra , selection rules and transition for vibrating rotator, intensities in rotation and vibration spectrum, parallel and perpendicular bands of linear molecules, Isotope effect-vibration , rotation.

5. ELECTRONIC SPECTRA OF DIATOMIC MOLECULES (PERIODS-8 HOURS)

Electronic energy curves, potential energy curves stable and unstable molecular states, vibration structure of electronic transitions, general formula, graphical representation, isotopes effect, rotational structure of electronic spectar, the branches of band , band head formation, shading of bands: Fortrat diagram, intensities in electronic bands-Vibrational structure-Frank Condon principle, absorption and emission, rotational structure , transition.

References:

1. Introduction to atomic and nuclear physics (Van Norstrand Reinhold (east-West

Press) by H. E. White)

2. Introduction to atomic spectra (Mc. Graw hill, International Edition) by H. E.

White)

3. Atoms and Molecules: An introduction for students of Physical chemistry (W. A.

Benjamin Inc. New York) by Martin Karplus and Richard N. Porter)

4. Atomic physics, (Oxford Master Series in atomic, optical and laser physics) by

Christopher J. Foot.

5. Introduction to atomic spectra (Mc. Graw hill, International Edition) by H. E. White

6. Molecular structure and spectroscopy , 2 nd edition (PHI learning Pvt. Ltd. New

Delhi) by G. Aruldhas

7. Fundamentals of Molecular Spectroscopy (McGraw-Hill Publishing Company by

Colin Banwell)

ES -302: CONDENSED MATTER PHYSICS

1. SPECIFIC HEAT AND LATTICE VIBRATIONS (PERIODS-7 HOURS)

Classical theory of specific heat and it's drawbacks, Einstein theory of specific heat, vibrational modes of a continuous medium, Debye approximation, The Born cut-off procedure, Vibrational modes of a finite one-dimentional lattice of identical and diatomic lattice.

2. FREE ELECTRON THEORY OF METALS (PERIODS-7 HOURS)

The free electron theory of metals, electronic specific heat, Response and relaxation phenomena, Drude model of electrical and thermal conductivity, the Fermi surface, electrical conductivity; effects of the Fermi surface, Fermi surfaces: its characteristics.

3. DIELECTRIC AND OPTICAL PROPERTIES OF INSULATORS

(PERIODS-12 HOURS)

Static fields: Macroscopic description of the static dielectric constant, The static electronic and ionic polarizabilities of molecules, Oriental polarization, The internal field according to Lorentz and the Clausius-Mosotti formula. Alternating fields: The complex dielectric constant and dielectric losses, dielectric losses and relaxation time, The Classical theory of electronic polarization and optical absorption. Ferroelectricity: General properties of ferroelectric materials, classification, ferroelectric domains.

4. MAGNETISM (12 HOURS)

Magnetic materials and their properties, Quantum theory of paramagnetism, Diamagnetism, Ferromagnetism: The Weiss molecular field and its interpretation, Temperature dependence of spontaneous magnetization. Antiferromagnetism: Molecular field theory, two sub lattice model.

5. SUPERCONDUCTIVITY (10 HOURS)

Introduction, Meissner effect, The critical field, Thermodynamics of superconducting transition: The heat capacity and stability of superconducting state, Electrodynamics of superconductors: The London equation, coherence

length and penetration depth, BCS theory of superconductivity, the condensate, The Josephson Tunneling: DC and AC effect, Introduction to high Temperature superconductivity.

References:

1. A. J. Dekker, Solid State Physics, Macmillan India Limited, 1991.

2. Charles Kittel, Introduction to Solid State Physics, , John Wiley and Sons.

3. H. P. Myers, Viva Books Private Limited, Second Edition.

4. N. W. Ashcroft and N. D. Mermin, Solid State Physics, CBS publishing Asia Ltd.

5. M. Ali Omar, Elementary Solid State Physics, Pearson Education.

ES 303: PHOTOVOLTAICS AND WIND ENERGY SYSTEMS

UNIT-1: SOLAR PHOTOVOLTAICS

(a) Introduction (PERIOD-4 Hours)

The Photovoltaic effect, Photovoltaic cells and power generation, some important definitions, Characteristics of Solar Cell: Photocurrent and quantum efficiency, dark current and open circuit voltage, efficiency, parasitic resistances, non-ideal diode behaviour

(b) Basic Principles of Solar Photovoltaics (PERIOD-6 Hours)

(c) Detailed balance: in equilibrium, under illumination, Work available from a photovoltaic device: photocurrent, dark current, limiting efficiency, effect of spectrum on efficiency, requirements for ideal photoconverters.

UNIT 2: SOLAR CELL: MATERIALS AND TECHNOLOGY (PERIOD-8 Hours)

Material Properties and synthesis techniques, solar cell and module properties, status and future prospects of: Silicon, cadmium telluride, copper indium diselenide Tandem cells and concentrating systems, dye-sensitized cells and organic solar cells

UNIT-3: SOLAR PHOTOVOLTAIC SYSTEMS (PERIOD-4 Hours)

Introduction: Stand alone SPV systems: consumer applications, solar home systems, Residential systems, hybrid systems; Grid connected SPV systems: decentralised and central grid connected SPV systems Design Principles: A typical Solar Home System: Solar Modules, Battery, Solar Controller (regulator), Lights; How to design a solar home system: Estimating the load, sizing ans specifying batteries, photovoltaic modules, System sizing worksheets. (8 Hours)

System Wiring: cable sizing, line losses, circuit protection; steps in design and installation, system maintenance (4 Hours)

Designing SPV systems with specific examples (at least two examples) (2 Hours)

UNIT-4: WIND TURBINE POWER (PERIOD-12 Hours)

Energy and Torque, Power output from an ideal turbine, aerodynamics, power output from practical turbines, transmission and generator efficiencies, energy production and capacity factor, torque at constant speeds, turbine shaft power and torque at variable speeds.

References:

1. The Physics of Solar Cells: Jenny Nelson, Imperial College Press

2. Photovoltaic Solar Energy Generation: A. Goetzberger, V.U. Hoffmann: Springer

3. The Solar Entrepreneur's Handbook: Geoff Stapleton, Gunaratne, Konings, Bandyopadhyay, WISE publication.

4. Wind Energy Systems by Dr. Gary L. Johnson

Semester-IV

ES-401 NUCLEAR PHYSICS

UNIT-1: NUCLEAR PROPERTIES (PERIOD-04 HOURS)

The nuclear radius, mass and abundance of nuclides, energy of nucleons in the nucleus, nuclear binding energy, nuclear angular momentum and parity, nuclear electromagnetic moments, nuclear excited states.

UNIT-2: NUCLEAR MODELS (PERIOD-08 HOURS)

Constitution of the nucleus; neutron-proton hypothesis, Nature of nuclear force, Inventory of stable nuclides, Liquid drop model: Semi-empirical mass formula, applications of semi-empirical mass formula, limitations of liquid drop model, Nuclear Shell model: Shell model and it's evidence, limitations of shell theory.

UNIT-3: RADIOACTIVITY (PERIOD-10 HOURS)

Radioactive disintegration and displacement law, Nuclear decay laws, half life, successive disintegrations, radioactivity equilibrium, radioactive dating methods. Alpha–decay: kinematics of alpha decay: alpha particle energy, penetration through the Coulomb barrier (Geiger-Nutall law) Beta-decay: The old beta decay theory and the neutrino hypothesis, Energy relations and Q-values in beta-decay, The Fermi theory of beta-decay, selection rule. Gamma decay: passage of gamma rays through matter, gamma ray spectra and nuclear energy levels, radiative transitions in nuclei.

UNIT-4: DETECTION OF NUCLEAR RADIATION AND THEIR MEASUREMENT

(PERIOD-06 HOURS)

Interaction of radiations with matter, gas filled counters, scintillation detectors, semiconductor detectors, counting statistics, energy measurements, coincidence measurement and time resolution, measurement of nuclear lifetimes.

UNIT-5: THE ACCELERATION OF CHARGED PARTICLES (PERIOD-06 HOURS)

The van de Graff machine, cyclotron, frequency-modulated cyclotron, the betatron and the electron synchrotron, the proton synchrotron, Linear accelerators,

UNIT-6: NUCLEAR FISSION AND FUSION (PERIOD-06 HOURS)

Characteristics of fission, Energy in fission, energy distribution between the fission fragments, energetic of fission process, cross section of neutron induced fission, controlled fission reactions, Q- value calculations, fission reactor, fission explosives, Basic fusion process, cross section of fusion reaction, critical temperature, Lawson criterion.

UNIT-7: ELEMENTARY PARTICLES (PERIOD-08 HOURS)

Classification of elementary particles, conservation laws, fundamental interactions in nature. Elementaary idea of CP and CPT invariance. Quark hypothesis: Classification, Quark structure of mesons and baryons, Gellman-Okubo mass formula.

References:

1. Introductory nuclear Physics, Kenneth S. Krane, John Wiley and Sons, 1988.

2. Nuclear Physics, Irving Kaplan, Addison-wesley publishing company, Inc, 1962.

3. Introduction to Nuclear Physics, H. A. Enge, Addison-Wesley, 1975.

4. Concepts of Nuclear Physics, Bernard L Cohen, Tata McGraw-Hill publishing company limited, 1971.

5. Basic ideas and concepts in Nuclear Physics, K. Heyde, IOP publishing limited, 2005.

6. Nuclear Physics, S. N. Ghoshal, S. Chand and company limited, 1994.

7. Introduction to Atomic and nuclear Physics, Harvey E. White, Van Nostrand Reinhold company, 1964.

ES-402: SOLAR THERMAL SYSTEMS

UNIT-1: SOLAR RADIATION (PERIOD-07 Hours)

The Sun, the solar constant, spectral distribution of extra-terestrial radiation, variation of extra-terrestrial radiation, definitions, direction of beam radiation, angles for tracking surfaces, extra-terrestrial radiation on a horizontal surface

UNIT-2: AVAILABLE SOLAR RADIATION: (PERIOD-07 Hours)

Instruments for measuring solar radiation and sunshine: pyrheliometer, pyranometer, sunshine recorder, apparent motion of the Sun, sunrise, sunset and the day length, local apparent time, atmospheric attenuation of solar radiation, empirical equations for predicting the availability of solar radiation, solar radiation on a tilted surface

UNIT-3: SELECTED HEAT TRANSFER TOPICS (PERIOD-08 Hours)

The electromagnetic spectrum, the blackbody, Planck's law and Wien's displacement law, Stephan-Boltzmann equation, Fourier's law, IR radiation exchange between grey surfaces, sky radiation, radiation heat transfer coefficient, Natural convection between flat parallel plates and between concentric cylinders, wind convection coefficient

UNIT-4: LIQUID FLAT PLATE COLLECTOR (PERIOD-10 Hours)

Introduction, Energy balance equation, transmittivity of cover systems, trasmissivityabsorptivity product, overall loss coefficient and heat transfer correlations, collector efficiency factor, collector heat removal factor, testing procedure, the evacuated tube collectors, Introduction to concentrating collectors: classification and types

UNIT-5: THERMAL ENERGY STORAGE (PERIOD-05 Hours)

Introduction, sensible heat storage: liquids, solids, analysis of a liquid storage tank; Latent heat storage

UNIT-6: SOLAR CONCENTRATORS: (PERIOD-11 Hours)

Concentration ratio, Acceptance angle, Stationary collectors: Compound parabolic collectors, Sun-tracking collectors: parabolic trough collector, Fresnel collector, parabolic dish reflector, Heliostat field collectors; optical and thermal performance of a concentrating collector.

References:

1. Solar Engineering of Thermal Processes: John A. Duffie and William A. Beckmann

2. Solar Energy: S.P. Sukhatme

ES-403: ENERGY AUDIT AND MANAGEMENT

UNIT-1: ENERGY AUDITING BASICS (PERIOD-3 Hours)

Introduction, types of energy audits, the audit process, pre-site work, post-site work, the audit report

UNIT-2: ENERGY ACCOUNTING AND ANALYSIS (PERIOD-5 Hours)

Introduction, electric demand, load factor, analyzing energy data, identifying potential measures, industrial audit opportunities

UNIT-3: ECONOMIC ANALYSIS AND LIFE CYCLE COSTING (PERIOD-10 Hours)

Introduction, Costs: categories, cash flow diagrams and tables, simple payback period cost analysis, economic analysis using the time value of money, discounted cash flow analysis, discounted cash flows: basics and single sum analysis, methodology using discounted cash flows, cost effectiveness measures using discounted cash flows, Life cycle costing

UNIT-4: ELECTRIC ENERGY MANAGEMENT (PERIOD-10 Hours)

Introduction, Power supply, motor and motor related terms, power factor, formulas and rules of thumb, electric motor operating loads, power meter, electric motor efficiency, comparing motors, motor efficiency management, Reference: Energy Management Handbook Sixth Edition Wayne C. Turner and Steve Doty

UNIT-5: LIGHTING (PERIOD-10 Hours)

Introduction, components of the lighting system, lamp characteristics, lamp types, ballasts, Luminaries, determining lighting needs, the lighting survey, safety issues, identifying potential EMOs.

UNIT-6: PROCESS ENERGY MANAGEMENT (PERIOD-10 Hours)

Introduction, steps for process improvement, motors and adjustable speed drives, air compressors, examples of process energy improvements, common energy management opportunities

References:

1. Handbook of Energy Audits Seventh Edition by A. Thumann and W.J. Younger

2. Guide to Energy Management (International Version) Fifth Edition by Barney Capehart, Wayne C. Turner and W.J. Kennedy